PATENT SPECIFICATION (11) 1 595 531

1 595 531

(21) Application No. 2635/78 (22) Filed 23 Jan. 1978 (19)
(31) Convention Application No. 7701958 (32) Filed 25 Jan. 1977 in
(33) France (FR)
(44) Complete Specification Published 12 Aug. 1981
(51) INT. CL.[3] G01L 1/22
(52) Index at Acceptance
G1W E3A3 E3D1 E3D611X

(54) FORCE MEASURING DYNAMOMETER DEVICE FOR A RAM OPERATED LIFTING JIB

(71) We, SOCIETE ANONYME FRANCAISE DU FERODO, a French Body Corporate, of 64 Avenue de la Grande-Armee, 75017 Paris, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates generally to the measurement of the tilting moment exerted in operation on the jib of a lifting mechanism by the load applied to it, and it relates more particularly to the case where the inclination of the jib is effected by one or more rams pivotally mounted on the one hand to the jib and on the other hand to the frame on which the jib is in turn hinged; for the sake of simplification the number of lifting rams thus used will assumed here to be reduced to one, although obviously this condition is not to be considered as constituting a limitation of the scope of application of the invention.

For the measurement of tilting moments in the manner desired it has already been proposed to utilise a dynamometer device comprising a pin which serves as pivot pin between, for example, the ram and either the jib or the frame to which the ram is connected, the said device forming by itself a force pickup and the said pin being fastened on the jib or frame, as the case may be, with a determined angular orientation in which one of its axial planes of symmetry substantially contains a measurement direction forming a determined angle with a selected reference line, the said pin further carrying, in planes parallel to the said plane of symmetry, a set of strain gauges so disposed as to be sensitive only to shear stresses.

A device of this kind has given and is still giving satisfactory operation.

The object of the present invention is the provision of a dynamometer device of this type, which has improved sensitivity.

The dynamometer device according to the invention, which is intended for equipping a lifting mechanism having a jib or lifting arm mounted for pivotal movement on a frame about a horizontal axis through the action of a ram pivoted on the one hand to the said jib and on the other hand to the said frame, for measuring the force exerted on the jib by the load applied to it, is of the kind in which for the purpose of measuring the component of a force in a measurement direction forming a determined angle with a selected reference line a pin serving as pivot pin between the ram and either the jib or the frame forms by itself a force pickup, the said pin being fastened on the jib or frame, as the case may be, with a determined angular orientation in which one of its axial planes of symmetry substantially contains the said measuring direction, and the said pin further carrying, in planes parallel to the aforesaid plane of symmetry, a set of strain gauges so disposed as to be sensitive only to shear stresses; the device is characterised in that the angular orientation of the said pin is such that the axial plane of symmetry of the pin corresponding to the said set of strain gauges forms an angle of 45° with the selected reference line, for the desired measurement of the force component in a measurement direction which itself forms an angle of 45° to the said reference line, and in that the said pin carries a second set of strain gauges disposed similarly to the first set so as to be sensitive only to shear stresses, the axial plane of symmetry of the said pin corresponding to this second set of strain gauges forming an angle of 135° to the selected reference line and therefore being orthogonal to the axial plane of symmetry corresponding to the first set of strain gauges, for the desired measurement of the force component in a second direction of measurement which in turn forms an angle of 135° to the said reference line.

Calculations show that with the aid of this arrangement the forces measured are greater, under otherwise equal conditions, than the forces measured by a dynamometer device in which the pin forming the force pickup carries only a single set of strain gauges.

The sensitivity of a dynamometer device of this kind is therefore improved, which is particularly advantageous as the signals usually received at the terminals of strain gauges are always relatively weak.

The characteristics and advantages of the invention will moreover be clear from the description given below by way of example and with reference to the accompanying diagrammatical drawings, in which:-

Figure 1 is a view in elevation of a jib type crane capable of being equipped with a dynamometer device according to the invention;

Figure 2 is a representative diagram of forces acting on a crane of this kind, with a resolution of forces belonging to the prior art;

Figure 3 is a similar diagram to that in Figure 2, with a resolution of forces according to the invention.

Figure 4 is a view in elevation and section, showing on a larger scale a detail of Figure 1 indicated by a box IV in that Figure and illustrating the dynamometer device of the invention;

Figure 5 is a view in axial section on the broken line V-V in Figure 4;

Figure 6 is a view in cross-section on the line VI-VI in Figure 5;

Figure 7 is a plan view on a larger scale, showing the arrangement, on the pin forming the dynamometer device of the invention, of the strain gauges carried by the said pin;

Figure 8 is a circuit diagram illustrating the connection of these strain gauges;

Figures 9 and *10* are similar diagrams to Figure 8, each relating respectively to a modified arrangement of the strain gauges in question; and

Figure 11 is a diagrammatical view in elevation and partial section of the pivot pins of the jib of the crane shown in Figure 1.

Figure 1 illustrates by way of example the application of the invention to a crane 10 equipped with a lifting jib 11, which is for example telescopic and which carries at its end a hook 12 coupled to an operating winch (not shown in the drawing).

The crane could equally well be a service machine equipped with a lifting arm carrying at its end a platform of any kind for work purposes, or a load handling machine, such as a lift truck, for example.

However this may be, a jib 11 of this kind is usually articulated about a horizontal pin 13 carried by a frame 14, the latter in turn forming a turret mounted for rotation about the vertical axis of a boss 15.

In known manner, the inclination of the jib 11 is effected by means of a lifting ram 16, the body 17 of which is hinged about a horizonal pin 18 on the frame 14, while its piston rod 19 is hinged about a horizontal pin 20 on the jib 11; clearly, the respective arrangements of the ram body 17 and piston rod 19 could be reversed in relation to one another and in relation to the frame 14 and jib 11, and the ram 16, which is a single ram in the drawing for the sake of simplicity, could equally be replaced by two or more rams.

The pin 20 which serves as pivot pin between the ram 16 and the jib 11 is fastened to the jib in a manner which will be described in detail hereinafter; briefly, as illustrated in Figures 4 and 5, the jib 11 is for this purpose provided on its bottom face with two parallel plates FL1, FL2, between which the pin 20 extends.

The piston rod 19 of the ram 16 is provided at its end with a boss 21 which engages rotatably over the pin 20.

A rotating pin and boss mounting is thus formed between the ram 16 and the jib 11, and a similar rotating pin and boss mounting hinges the jib 11 to the frame 14; as indicated in Figure 11, the pin 13 of this second rotary mounting is assumed to be fixed on the jib 11, while the corresponding boss 23 is assumed to be fastened to the frame 14.

For convenience of description, with reference to Figure 2, the pins 13, 18, and 20 are assumed to be reduced to pivot points, the jib 11 to be reduced to a straight line passing through the pins 13 and 20, and the ram to be reduced to a straight line extending between the pins 18 and 20, and the following designations will be employed;

FC for the load applied to the jib 11, at the end thereof;

FV for the force developed axially by the lifting ram 16 at its point of connection 20 to the jib 11;

L for the length of the jib 11 between its point of connection 13 to the frame 14 and the point at which the load FC is applied to it:

ℓ for the distance along the jib 11 between the pivot point 13 on the frame 14 and the pivot point 20 of the ram 16 on the jib ;

d the distance between the pivot points 13 and 18 on the frame 14 of the jib 11 and the ram 16;

A for the angle of inclination of the jib 11 to the horizontal H.

In order to ascertain the load FC, and therefore the tilting moment resulting therefrom, it has already been proposed to measure the component, in a measurement direction D forming an angle of 90° with a reference line LR selected to coincide with the line connecting the pivot points 13 and 20, of the force FC developed axially by the raising ram 16 (Figure 2).

Between the component in question (designated FVP in Figure 2) and the load FC, equality of moments about the pivot 13 of the jib 11 leads in fact to the following relationship:

$$\overline{FC} = \overline{FVP} \times \frac{\ell}{L} \times \frac{1}{\cos A} \qquad (1)$$

Because of this relationship, the calculation of the load FC presupposes knowledge of the angle of inclination A of the jib 11 relative to the horizontal H, and also knowledge of the component FVP, in the direction D, of the force developed axially by the raising ram 16.

The angle of inclination A can easily be measured.

With regard to the component FVP, it has been proposed to equip the pin 20, in two planes parallel to one and the same plane of symmetry, with strain gauges disposed in such a manner that they are sensitive only to shear stresses, and to fasten this pin 20 on the hoisting jib 11 with an angular orientation in which the axial plane of symmetry in question substantially contains the direction D of the desired component FVP, the pin 20 thus forming by itself a force pickup at the terminals of which a signal proportional to the magnitude of this component can be obtained.

According to the invention, it is proposed to take into account a resolution of the force FV developed axially by the raising ram 16 in two directions D_1 and D_2 orthogonal to one another, the first of which directions forms an angle of 45° with the reference line LR defined above, and the second of which thus forms an angle of 135° with the said reference line (Figure 3).

If in fact the components of the force FV in the measurement directions D_1 and D_2 thus defined are designated FV_1 and FV_2, equality of the moments about the pivot point 13 of the jib 11 leads to the following relationship:

$$\overline{FC} = (\overline{FV_1} + \overline{FV_2}) \times \frac{\ell}{L} \times \frac{\cos 45°}{\cos A} \qquad (2)$$

Comparison of the relationships (1) and (2) gives the following result:

$$\overline{FV_1} + \overline{FV_2} = \frac{1}{\cos 45°} \times \overline{FVP} = \sqrt{2}\,\overline{FVP} \simeq 1.4\,\overline{FVP}$$

Measurement of the forces FV_1 and FV_2 therefore advantageously leads to a stronger signal than measurement of the force FVP.

For the measurement of the force FV_1 the pin 20 (Figures 4 to 7) carries in two diametrically opposite planes, on each side of an axial plane of symmetry P_1, strain gauges disposed in such a manner as to be sensitive only to shear stresses.

In practice, the pin 20 carries, on a flat F_1 disposed near one of is ends, two strain gauges J1A and J1B disposed at right angles to one another, each lying at 45° in relation to the axial direction of the pin carrying it, the said flat F_1 preferably being plane and parallel to the axial plane of symmetry P_1 defined above.

In a similar arrangement, the pin 20 carries near its other end, on a flat F_2 coplanar to the previously mentioned flat F_1, two strain gauges J2A and J2B disposed at right angles to one another, each at 45° in relation to the axial direction of the pin 20.

In a plane symmetrical to the plane of the flats F_1 and F_2, in relation to the axial plane of symmetry P_1 previously defined, the pin 20 carries similarly, near its ends and on flats F'_1 and F'_2 strain gauges J'1A, J'1B and J'2A and J'2B which are respectively symmetrical to the strain gauges J1A, J1B and J2A, J2B.

For the measurement of the force FV2, the pin 20 carries on two parallel flats G_1 and G'_1, which are formed at points corresponding to the flats F_1 and F_2 and are at right angles thereto and are therefore both parallel to an axial plane of symmetry P_2 of the pin 20 orthogonal to its axial plane of symmetry P_1, strain gauges K1A, K1B and K'1A, K'1B disposed respectively at right angles to one another on the respective flats, each at 45° in relation to the axial direction of the pin 20 carrying it.

In a similar arrangement, the pin 20 carries at its other end, on flats G_2 and G'_2 which are both parallel to the plane of symmetry P_2 and are disposed at 90° in relation to the flats F_2

and F'_2, at points corresponding thereto, strain gauges K2A, K2B and K'2A, K'2B disposed at right angles to one another on the respective flats, each at 45° in relation to the axial direction of the pin 20.

Strain gauges of the same index in the sets of strain gauges J, J' to K, K' have the same inclination in relation to the axial direction of the pin 20.

In practice, as illustrated, the various strain gauges described above are carried by portions T_1 and T_2 of reduced diameter of the pin 20, each of these portions of reduced diameter extending between two portions of larger diameter of the pin 20, namely a middle portion TM with which the flanged end 21 of the rod 19 of the raising ram 16 cooperates, and end portions TE1 and TE2, which have the same diameter as the middle portion TM and with which the plates FL_1 and FL_2, by which the jib 11 carries the pin 20, cooperate.

As mentioned above, this pin 20 is fastened on the plates FL_1 and FL_2, for example by keying (not shown).

According to the invention its angular orientation is such that its axial plane of symmetry P_1 forms an angle of 45° with the reference line LR defined above, and therefore contains the direction D_1; its plane of symmetry P_2 consequently conjointly forms an angle of 135° with the reference line LR and thus contains the direction D_2.

The two sets of strain gauges described above, namely on the one hand the set associated with the plane of symmetry P_1 of the pin 20 and on the other hand the set associated with the plane of symmetry P_2 of this pin, at right angles to the first-mentioned set, can advantageously be mounted within one and the same measuring bridge because of the inclination at 45° and 135° of these planes of symmetry on the selected reference line LR.

In accordance with the arrangement shown in Figure 8, the strain gauges J1A, J2A and K1A, K2A, which have the same inclination in relation to the axial direction of the pin 20, are disposed in series in one of the branches of a bridge of this kind, the gauges J'1A, J'2A and K'1A, K'2A disposed in flats parallel to those carrying the previously mentioned strain gauges are disposed in series in the opposite branch of the said bridge, and, in a similar arrangement, the gauges J1B, J2B and K1B, K2B on the one hand and J'1B, J'2B and K'1B, K'2B on the other hand are respectively disposed in series in the two opposite branches of the said bridge.

Thus, the two sets of strain gauges carried by the pin 20 are incorporated in one and the same measuring bridge.

On one of the diagonals of this bridge measuring voltage V is applied, as indicated in Figure 8, and on the other diagonal a measuring voltage M is obtained which is an image of the sum of the shear stresses to which the pin 20 is subjected in the directions F_1 and D_2, and which consequently is an image of the sum of the components FV_1 and FV_2, in those two directions, the force FV developed axially by the raising ram 16.

Figures 9 and 10 illustrate two other possible connection arrangements.

According to Figure 9, for each branch of the bridge in question the strain gauges associated with a plane of symmetry P_1 of the pin 20 are in parallel in relation to the strain gauges of the pin which are associated with its plane of symmetry P_2.

According to Figure 10, for each branch of the bridge in question the various strain gauges are all in parallel.

In the foregoing it has been assumed that for each rotating assembly associated with the jib 11, the pin forming the pivot pin corresponding thereto was in contact at all points of its periphery with the flange in which it is engaged.

If this is the case, the reference line LR selected is contained in the plane passing through the geometrical axis of each of these pivot pins 13, 20.

In practice however, the contact between a pivot pin of this kind and corresponding flange is made only on one of its generatrices.

Thus, for example, if, as illustrated in Figure 11, the pivot pin 13 is carried by the jib 11 while the corresponding flange 23 is fastened to the frame 14, the generatrices on which the pivot pins 15 and 20 will be in contact with the flanges 23 and 21 corresponding thereto are in substantially diametrically opposite positions.

This being the case, the reference line selected belongs to the plane which contains both of the contact generatrices in question.

As illustrated in Figure 11, this line LR forms an angle with the line joining the centres of the circles representing the pivot pins 13 and 20.

When installing the pin 20 forming a force pickup it is preferable, when giving it its angular orientation, to take into account the reference line LR thus defined, and it is therefore in relation to this line LR that the planes of symmetry P_1 and P_2 of the said pin 20 must be oriented.

The present invention is not limited to the embodiment described and illustrated, but includes any alternative embodiments within the scope of the appended claims.

In particular, the scope of the invention will not be exceeded if the pin forming the force

pickup is not disposed at the pivot 20 of the lifting ram 16 on the jib 11, as more particularly described hereinabove, but is disposed at the pivot point 13 of the jib 11 on the frame 14.

Furthermore, as indicated in broken lines in Figure 7 for the flat F_1 carrying the strain gauges J1A and J1B, a flat of this kind may extend over the entire axial length of the corresponding portion T_1 of reduced diameter of the pin 20 and extend at least partially into each of the portions TE_1 and TM of larger diameter which are disposed on each side of the said portion T_1.

This arrangement has the consequence of advantageously assisting separation between the forces involved, by relieving the strain gauges of the action of restraint caused by the portions of larger diameter of the pin 20.

Finally, for the positioning of the strain gauges, types of holders other than simple flats can be used, for example grooves.

WHAT WE CLAIM IS:-

1. A dynamometer device for a lifting mechanism having a jib or lifting arm mounted for pivotal movement on a frame about a horizontal pin through the action of a ram pivoted on the one hand to the jib and on the other hand to the frame, said dynamometer device being adapted to measure the force exerted on the jib by a load applied to it and being of the kind in which, for the purpose of measuring the component of a force in a measurement direction forming a determined angle to a selected reference line, a pin serving as pivot pin between the ram and either the jib or the frame forms by itself a force pickup, the said pin being fastened on the jib or frame with a determined angular orientation in which one of its axial planes of symmetry substantially contains the said measurement direction, and the said pin further carrying, in planes parallel to the said plane of symmetry, a set of strain gauges so disposed as to be sensitive only to shear stresses, the device being characterised in that the angular orientation of the said pin is such that the axial plane of symmetry of the pin corresponding to the said set of strain gauges forms an angle of 45° with the selected reference line, for the desired measurement of the force component in a measurement direction which itself forms an angle of 45° with the said reference line, and in that the said pin carries a second set of strain gauges disposed similarly to the first step so as to be sensitive only to shear stresses, the axial plane of symmetry of the said pin corresponding to this second set of strain gauges forming an angle of 135° to the selected reference line and therefore being orthogonal to the axial plane of symmetry corresponding to the first set of strain gauges, for the desired measurement of the force component in a second direction of measurement which itself forms of angle of 135° with the said reference line.

2. A dynamometer device according to Claim 1, characterised in that the strain gauges are carried by portions of reduced diameter of the pin forming a force pickup at the ends thereof, and the said portions of reduced diameter each extend between two portions of larger diameter, one of which cooperates directly with the ram, while the other of which cooperates directly with the jib or frame through the corresponding pivot of the ram.

3. A dynamometer device according to Claim 2, characterised in that the holder receiving a strain gauge extends over the entire axial length of the corresponding portion of reduced diameter of the pin and extends at least partially into each of the portions of larger diameter of the pin between which the portion of reduced diameter is situated.

4. A dynamometer device according to any of Claims 1 to 3, in which the pin forming the force pickup is engaged, in a rotating arrangement, in a boss for the ram, the said pin being in contact with the said boss by at least one of its generatrices, hereinafter referred to as contact generatrix, while a rotating pin and boss mounting of similar type effects the pivoting of the jib to the frame, characterised in that the angular orientation of the pin forming a force pickup is such that the selected reference line belongs to the plane containing both the contact generatrices of each of the rotating mounting in question.

5. A dynamometer device according to any of Claims 1 to 4, characterised in that the two sets of strain gauges are incorporated in one and the same measuring bridge.

6. A dynamometer device substantially as hereinbefore described with reference to the accompanying drawings.

PAGE, WHITE & FARRER,
Chartered Patent Agents,
27 Chancery Lane,
London, WC2A 1NT.
Agents for the Applicants.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1981.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

FIG.1

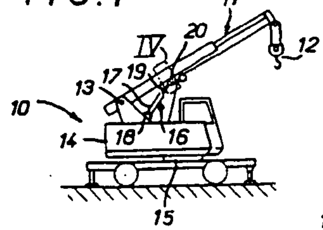


FIG. 2

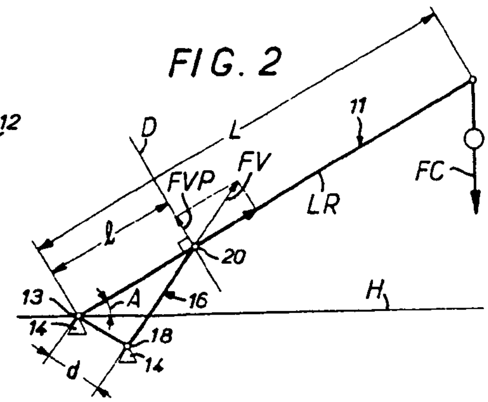


FIG.4

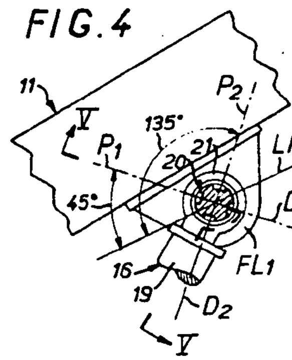


FIG.3

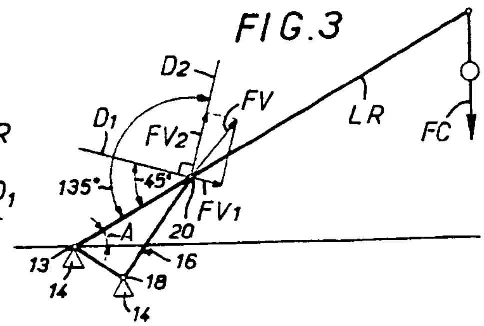


FIG.5

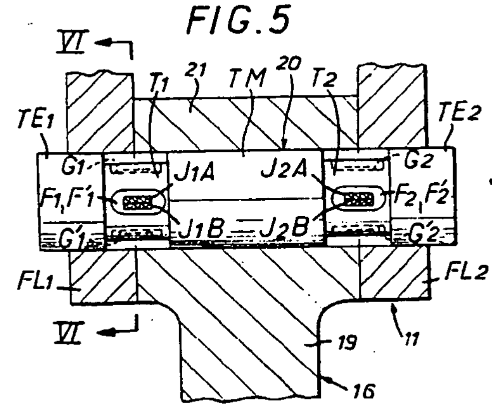
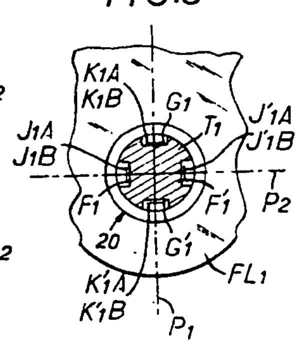


FIG.6



1595531 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

FIG. 7

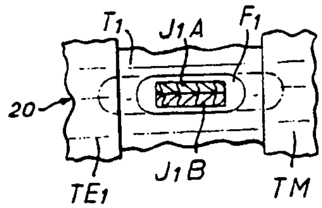


FIG. 9

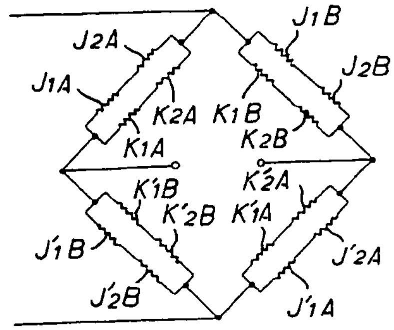


FIG. 8

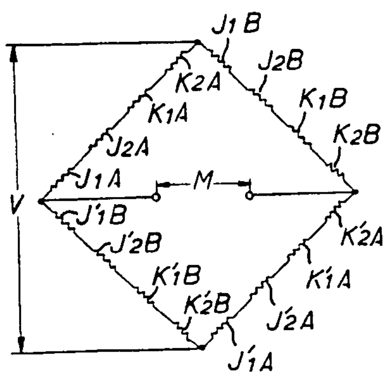


FIG. 10

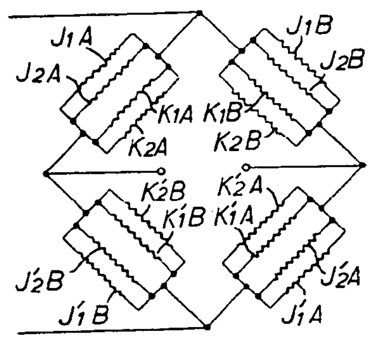


FIG. 11